ROOTING greenwood cuttings of SUGAR MAPLE — effect of clone and medium

by
William J. Gabriel
James W. Marvin
Fred H. Taylor

STATION PAPER NO. 144 · NORTHEASTERN FOREST EXPERIMENT STATION · 1961
U.S. FOREST SERVICE · U.S. DEPARTMENT OF AGRICULTURE · UPPER DARBY, PA.
RALPH W. MARQUIS, DIRECTOR

The Authors . . .

WILLIAM J. GABRIEL *holds a B.S. degree from the University of New Hampshire, M.F. degrees from Duke and Harvard Universities, and is now completing his Ph.D. thesis as a final requirement for that degree at Harvard. A veteran of 4 years in the Air Force, he worked as forest geneticist for a year at the Maria Moors Cabot Foundation. In 1954 he joined the U.S. Forest Service's Northeastern Forest Experiment Station and served for 2 years at the Morris Arboretum. He was transferred in 1956 to his present post as geneticist at the Experiment Station's research center at Burlington, Vermont.*

JAMES W. MARVIN *took his B.S. and M.S. degrees at the University of Vermont in 1932 and 1933. He worked as a Laboratory assistant from 1933 to 1939 while attending Columbia University, where he received his Ph.D. in botany in 1939. He joined the University of Vermont Botany Department and the Vermont Agricultural Experiment Station in Burlington 1939. A recognized authority on the physiology of sugar maples, Dr. Marvin is serving as plant physiologist in the Agricultural Experiment Station and since 1944 has been Chairman of the Botany Department of the University of Vermont.*

FRED H. TAYLOR *was awarded his B.S. degree from Massachusetts State College in 1933. After a year as assistant in botany at Radcliffe College, he served as Austin teaching fellow for 1 year and later as assistant in biology for 3 years at Harvard. He received M.S. and Ph.D. degrees from Harvard, majoring in botany. He taught at Clemson College from 1939 to 1943 before joining the staff at the University of Vermont, where he is now Professor of Botany. Dr. Taylor has been associated with anatomical studies of vascular plants, and as plant morphologist at the Vermont Agricultural Experiment Station he has been conducting investigations of the anatomy and physiology of sugar maples.*

ROOTING *greenwood cuttings* *of* SUGAR MAPLE

effect of clone and medium

by
William J. Gabriel
James W. Marvin
Fred H. Taylor

THE COVER PHOTO *shows an example of the excellent rooting obtained with sugar maple.*

The Problem of Rooting

IN FOREST GENETICS work, an important method for evaluating selected trees is clonal testing. Because a clone consists of a number of individuals propagated from the same parent tree, clonal testing must begin with vegetative propagation. As a general rule, the most convenient and practicable way to propagate woody plants vegetatively is by stem cuttings. However, some species are difficult to root. One of these is sugar maple *(Acer saccharum* Marsh.); and the cuttings that do strike root are difficult to bring through to successful establishment.

When tree-improvement work in sugar maple was started at our research center at Burlington, Vermont, in 1956,[1] one of the high-priority research jobs was to develop suitable methods for vegetative propagation. Although grafting is one well-established method for such propagation it would be a questionable method for clonal testing of sugar maple because of the possibility that the rootstock might affect the sugar content of sap in the scion. Therefore it was decided

[1]A cooperative project of the Vermont Agricultural Experiment Station and the Northeastern Forest Experiment Station.

to limit the studies, at least for the present, to propagation by means of cuttings. Research on propagation by cuttings has two distinct phases: (1) how to induce cuttings to root; and (2) how to carry rooted cuttings over winter in a healthy condition, capable of continuing growth the next spring.

This paper deals with tests on the rooting of greenwood cuttings, for which some positive results can be reported. The problem of how to carry rooted cuttings over winter remains to be solved; it will be touched upon only very briefly.

Earlier Studies

Past work has shown that to root cuttings taken from mature trees of sugar maple is a difficult task. Gardner *(8)* was relatively successful in rooting cuttings from a young seedling, but had complete failure with cuttings from a mature tree. Snow *(12)* was able to root sugar maple cuttings, but apparently worked only with juvenile individuals. Afanasiev *(1)* reported nearly complete failure, rooting only 1 of 660 sugar maple cuttings; he did not mention the age of the parent trees.

Studies of variables affecting the rooting of sugar maple cuttings by Dunn and Townsend *(5)*, Enright *(7)*, and Snow *(12)* contain little information on the influence of the rooting medium. Patton and Riker *(11)* found that builder's sand is a more desirable rooting medium for eastern white pine cuttings than various mixtures of sand, peat, compost, and fertilizer. A mixture of sand and vermiculite was shown by Mergen *(10)* to be superior to sand as a rooting medium for slash pine. Dunn and Eggert *(6)* believe that sugar maple cuttings root best in sawdust. Jalil and Sharpe *(9)*, working with peach cuttings, found no significant differences in rooting among several mixtures of coarse or fine perlite and peat, but coarse perlite alone resulted in significantly less rooting.

Snow *(12)* observed that 4-inch greenwood cuttings of sugar maple rooted somewhat better than 6-inch cuttings. Dunn and Townsend *(5)*, though they did not make a similar

comparison, found 4- to 6-inch cuttings better than longer or shorter ones.

Dunn and Townsend *(5)* and later Dunn and Eggert *(6)* reported that growth regulators had little or no effect on the rooting of sugar maple cuttings. Tests of indolbutyric, indolacetic, p-chlorophenoxyacetic, and napthalene acetic acid at various concentrations, and Hormodin 3 powder, showed only a slight increase in rooting for 4 of the 16 treatments.

Clonal variation in the rooting of sugar maple cuttings from four trees has been reported by Dunn and Eggert *(6)*. Such variation also was mentioned in earlier work by Dunn and Townsend *(5)*. Clonal variation in the rooting of red maple was reported by Snow *(12)*. Doran *(3)* and Thimann and Behnke *(14)* have made extensive reviews of the literature concerned with rooting of woody cuttings.

Materials & Methods

The main objectives in our study were to determine the variation among sugar maple clones in the rooting of cuttings, and to compare three materials as rooting media. In view of the poor responses to root-promoting chemicals that have been reported by Dunn and co-workers, no chemical treatments were included in the study.

The main experiment discussed in this paper was conducted in 1957; it was followed by a re-test of certain clones in 1958. For the 1957 experiment, cuttings were collected from 46 mature maples in 5 states: 34 trees in Vermont, 6 in Massachusetts, 3 in Ohio, 2 in New Hampshire, and 1 in New York. Selection of trees was based upon sugar production--most of them were phenotypically high producers. However, a small number of low and intermediate producers were included for comparative purposes.

The study plan called for 216 greenwood cuttings from each tree or ortet[2] --a total of 9,936 cuttings from the 46

[2]Original seedling plant from which clonal material is derived (13).

trees. Each cutting was to be at least 4 inches long. Lateral and terminal twigs from all parts of the tree were acceptable. However, because of insufficient current growth, the full number of cuttings was not obtained from some trees (only 42 in one instance), and some cuttings as short as 2 inches were taken. Total number of cuttings obtained was 7,822. All cuttings were taken during the latter part of June and early July. Enright *(7)* has since confirmed that sugar maple cuttings gathered during these months root most successfully.

Processing of cuttings generally followed the procedure outlined by Dunn and Townsend *(5)*. The twigs were stripped of all but two or three of the last-formed leaves, cut just below the node to length, and then placed in the rooting media. Cuttings were spaced 2 x 3 inches in the media and were covered to within ½-1 inch of their tops.

The three rooting media tested were: (1) sawdust, (2) fine perlite, and (3) a mixture of equal parts of sphagnum moss, sand, and peat.

Well-rotted hardwood sawdust was selected as one of the media because of the success that Dunn and Townsend *(5)* had with sawdust in previous work with sugar maple. Perlite, the second medium tested, is an inorganic granular material of volcanic origin that Teuscher[3] found to be satisfactory for rooting various woody plants. It is also used by some commercial nurserymen for this purpose. A mixture of sphagnum moss, peat, and sand was included as an example of a denser rooting medium.

The rooting bed consisted of wooden flats, 24 x 18 x 6 inches, placed side by side in the open between two greenhouses on the University of Vermont campus (fig. 1). A wooden framework covered with 90-percent Saran shade cloth was constructed over the flats to reduce insolation and to provide a measure of protection from stray animals.

The bottoms and lower sides of the flats were perforated and the flats were elevated about 2 inches above the ground for drainage purposes. Before filling the flats with

[3]Teuscher, H., curator, Montreal Botanical Garden, Parks Department, Montreal, Canada. Personal communication, 1957.

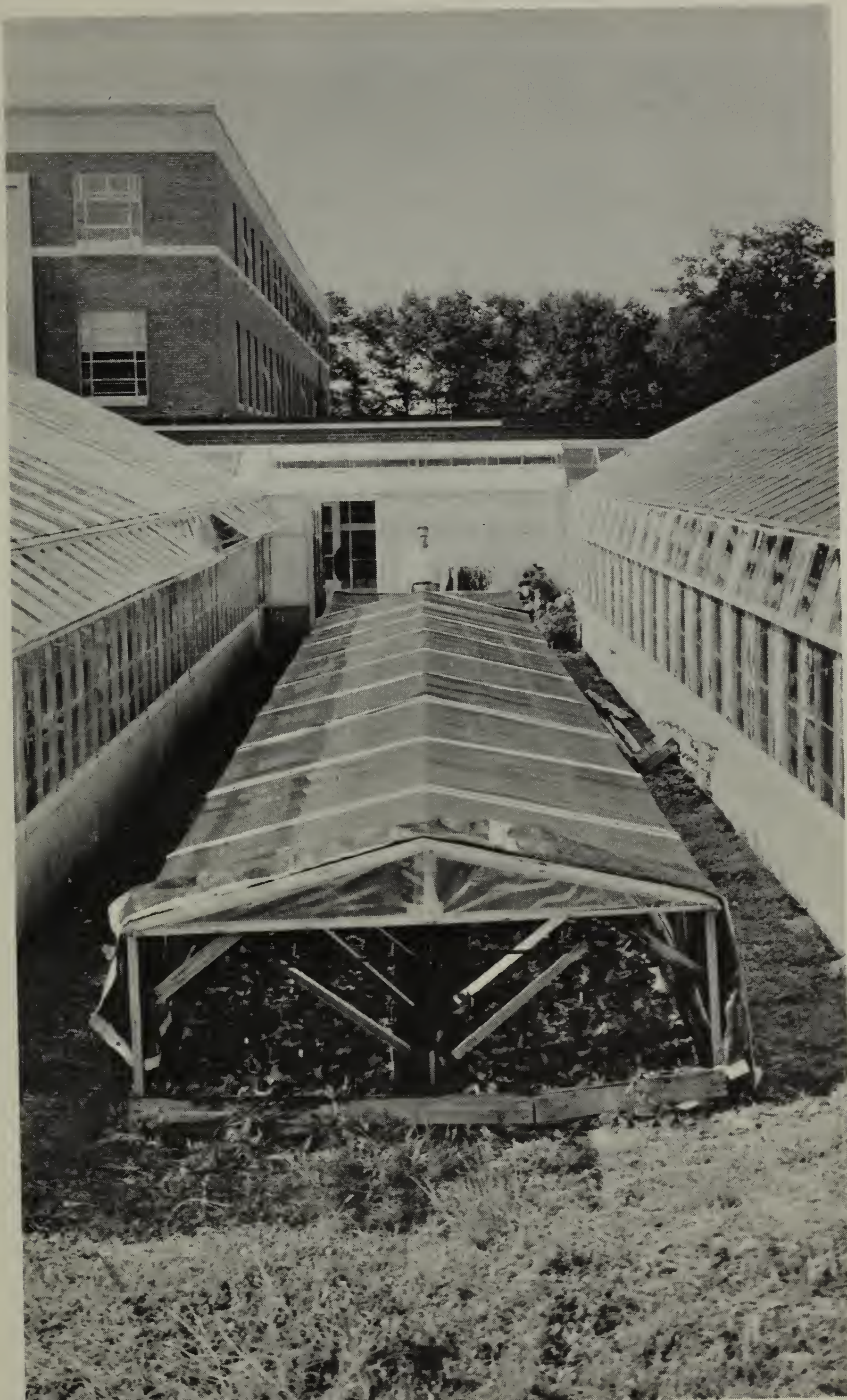

Figure 1.--*The outdoor rooting bed used in the sugar maple experiment. Saran cloth covering provided shade.*

Figure 2.--*Close view of the rooting bed, showing the overhead watering system. The cuttings, in wooden flats, were watered by an automatic intermittent mist system.*

rooting medium, a layer of garden soil 1 to 1½ inches deep, sprinkled with soil taken from a sugar maple stand, was spread in the bottom of each one. This was done on the theory that the production of fine absorbing roots and the development of mycorrhizae thus might be stimulated.

An overhead intermittent mist system provided moisture for the cuttings (fig. 2). During the initial phase of the experiment, automatic control was provided by an electronic leaf and solenoid valve; these were replaced later by a time switch control operating on a 1-minute interval between sprays. Duration of the spray varied from 1 to 2 seconds and was determined by the microclimate outside the rooting bed, the cuttings receiving more spray during periods of drying winds and low humidity. Required adjustments

were made manually. The mist was stopped at night and started again in the morning by means of a second time switch.

The experimental layout for statistical analysis was in the form of a split-plot design, with rooting media assigned to main plots and clones to sub-plots. The 3 rooting media were located at random in each of 2 blocks; cuttings from each of the 46 trees were randomized by clonal groups in each of the 6 main plots. Clones thus could be subjected to more sensitive comparisons than media.

In 1958, the 1957 experiment was repeated in part, using 11 of the same clones. Of these, 6 were among the highest rooting clones and 5 among the lowest. The primary purpose for selecting clones at either end of the order of rooting percentage was to further investigate clonal variation in rooting. The cuttings were treated essentially the same in both studies.

Results & Discussion

Effect of Clone on Rooting

In the 1957 test, a marked variation in rooting was found among clones. The range was from 46.1 percent to 1.4 percent (table 1). The results of an analysis of variance on the percentage of cuttings that rooted in 1957, using an angular transformation *(2)*, are presented in table 2.

In the 1958 study, differences in rooting among clones again were significant. But the ranking of the 11 clones on the basis of rooting percentage was much changed from that of 1957 (table 3). Moreover, a wide variation in rooting percentage between the 2 years was evident. Similar variations in results have been reported by Duffield and Liddicoet *(4)*, and by Patton and Riker *(11)*.

While it is possible that some minor variations may have occurred in the handling of the cuttings, it is felt that they would account for no more than a small part of the differences in rooting between the 2 years. It seems more

Table 1.--*Rooting percentages of greenwood cuttings from each of 46 sugar maple trees, 1957*

Rank	Clone No.	Total cuttings	Cuttings rooted	Rank	Clone No.	Total cuttings	Cuttings rooted
1	K-102	102	46.1	24	H-577	216	10.7
2	P-457	216	43.1	25	K-276	208	10.1
3	NY-394	42	38.1	26	NH-5	203	8.9
4	K-107	216	35.7	27	P-390	216	8.8
5	K-238	96	32.3	28	K-232	181	8.8
6	K-63	84	28.6	29	K-228	216	8.8
7	P-500	60	26.7	30	K-110	216	8.3
8	K-234	184	26.6	31	H-655	216	8.3
9	NH-3	150	22.7	32	K-292	120	8.3
10	H-578	216	21.8	33	K-38	150	8.0
11	K-226	138	21.0	34	K-65	113	7.1
12	P-486	216	20.1	35	K-261	216	5.6
13	H-545	216	19.0	36	K-60	131	5.3
14	K-286	161	17.4	37	K-227	210	4.8
15	P-526	133	17.3	38	P-489	168	4.8
16	P-392	216	17.2	39	H-664	216	4.6
17	0-6	120	16.7	40	P-548	216	4.2
18	K-59	102	15.7	41	P-459	150	4.0
19	P-491	216	15.3	42	P-397	180	3.3
20	P-463	216	11.6	43	H-665	216	2.8
21	P-480	132	11.4	44	0-2	102	2.0
22	0-4	216	11.1	45	K-301	126	1.6
23	P-499	172	11.1	46	K-230	216	1.4

likely that the differences between years resulted from differences in the physiological condition of the cuttings at the time they were taken from the trees. We have no information, however, on what those physiological differences might be.

Effect of Medium on Rooting

In the latter part of September, the cuttings were lifted and scored for rooting. Rooted cuttings were potted preparatory to hardening-off and winter storage. It was observed that the layer of soil placed in the bottom of each flat was a detriment rather than an aid in establishing root systems. Roots entering the soil layer invariably were attacked by fungi. Since the soil was of rather heavy texture, impeded drainage probably was mainly responsible for the poor condition of the roots.

Of 1,052 cuttings that rooted in all the media in the 1957 test, 45 percent were in perlite, 35 percent in sawdust, and 20 percent in the sphagnum-peat-sand mixture. The analysis of variance (table 2) indicated a significant differ-

ence in rooting due to medium. Orthogonal comparisons showed that the difference in rooting percentage between perlite and sawdust was not significant, but that the difference between the sphagnum-peat-sand mixture and the mean for perlite and sawdust was significant. Interaction between clone and medium had no significant effect on the percentage of cuttings that rooted.

In the 1958 study, the effect of medium on rooting of cuttings was not significant. This may reflect some attribute of the 11 clones used in 1958, since the 1957 data for

Table 2.--*Analysis of variance of the 1957 split-plot experiment on rooting of greenwood sugar maple cuttings*

(Data transformed by angular transformation)

Source of variation	Degrees of freedom	Mean square	F
Main plots:			
Block	1	18.29	0.1997
Rooting medium	2	2766.82	*30.21
Main plot error	2	91.58	--
Subplots:			
Clone	45	603.371	***4.54
Clone x medium	90	101.01	--
Subplot error	135	132.91	--

*Significant at 5.0-percent level.

***Significant at 0.1-percent level.

Table 3.--*Percentages of rooting in 1957 and in 1958 for cuttings of 11 clones re-tested in 1958, and the ranking of the clones for each year*

Clone No.	1957 rooting			1958 rooting	
	Ranking		Percent	Ranking	Percent
	(*)	(**)			
K-102	1	(1)	46.1	8	27.9
P-457	2	(2)	43.1	3	52.8
K-107	3	(4)	35.7	1	85.6
K-238	4	(5)	32.3	7	29.0
K-234	5	(8)	26.6	5	35.4
P-486	6	(12)	20.1	9	25.7
K-228	7	(29)	8.8	6	33.2
K-60	8	(36)	5.3	11	7.4
K-227	9	(37)	4.8	10	22.3
P-459	10	(41)	4.0	4	37.7
P-397	11	(42)	3.3	2	69.9

*Ranking of the 11 clones tested in 1958, based on 1957 results.

**Ranking of 11 clones tested in 1958 among the 46 clones tested in 1957.

Figure 3.--*A rooted cutting of sugar maple. This cutting was from a clone that rooted well even though none of the cuttings were more than 2 inches long.*

these clones, when analyzed separately, showed no significant effect of medium on rooting.

Although in both studies, the differences in rooting between perlite and sawdust were not significant, the use of perlite in preference to sawdust has some merit. The former is not an organic substance and would tend to be less favorable than sawdust for the growth of fungi and bacteria. Perlite is superior in drainage, and its moisture-holding capacity and porosity are as good or better than that of

sawdust. Perlite compares favorably in dry-weight and, although it is relatively low in cost, it may be washed, dried, and re-used.

Length of cuttings apparently is not so important as was previously thought (fig. 3). In certain of the better rooting clones, cuttings less than 4 inches long were successfully rooted; one clone rooted well with no cutting longer than 2 inches. However, thin and spindly cuttings probably should be avoided whenever possible because they are likely to be of low vigor.

Treatment after Removal from Rooting Bed

The rooting of sugar maple cuttings is only the first step toward establishing material for clonal outplantings. In the 1957 study the rooted cuttings were stored over winter in a root cellar. Temperatures ranged from 33° to 40°F., averaging 37°. Relative humidity was between 95 and 100 percent at all times. Probably because of the high humidity and poor ventilation, the cuttings became badly molded during the storage period. All cuttings died either during the winter or shortly after breaking dormancy.

Cuttings rooted during the summer of 1958 were over-wintered at four different controlled temperatures for comparison of survival and growth. Data collected during this study have not yet been analyzed. However, a limited number of cuttings broke dormancy in the spring of 1959 and were outplanted in the nursery. The majority of these had been over-wintered at 33°F. Second-year survival of the outplanted rooted cuttings was approximately 85 percent.

Although some small measure of success was achieved in over-wintering the 1958 cuttings, determination of the conditions required to carry a satisfactory percentage of rooted cuttings over winter remains a major problem to be solved in establishing clonal stocks of sugar maple. The cause of the high mortality in storage is not known. However, a starch test on some of the 1957 cuttings after their death in storage showed little or no starch present. This may mean that, for some reason, the cuttings failed to accumulate food reserves in the fall, or that accumulated

reserves were dissipated during the winter, and thus were inadequate to support the renewal of growth in the spring. It is possible that some sort of conditioning treatment during the fall before storage might increase survival. Studies along this line are now in progress, together with further studies of storage conditions.

Summary

An investigation was made in 1957 and 1958 of the effects of clone and rooting medium on the rooting of greenwood cuttings of sugar maple.

A significant difference in rooting ability was found among 46 clones in the 1957 study and among 11 of the same clones in the 1958 study. For the 11 clones that were tested both years, both the average and the individual percentages of the cuttings that rooted differed widely between years.

Of three rooting mediums tested, perlite and sawdust each gave rooting percentages that were significantly higher than those obtained with a mixture of equal parts of sphagnum moss, peat, and sand. No statistical significance in rooting was found between perlite and sawdust.

Differences in rooting of cuttings due to the interrelated effects of clones and media were not statistically significant.

Excessive mortality of the rooted cuttings occurred during winter storage. The 1957 cuttings, which were stored in a root cellar at about 37°F. under high humidity, all died. Only a small percentage of the 1958 cuttings survived winter storage under different degrees of controlled refrigeration.

Literature Cited

1. Afanasiev, M.
   1939. Effect of indolebutyric acid on rooting of some deciduous forest trees. Jour. Forestry 37: 37-41.

2. Bliss, C. I.
   1937. The analysis of field experimental data expressed in percentages. Plant Protection 12: 67-77. Leningrad. (In Russian.)

3. Doran, W. L.
   1957. Propagation of woody plants by cuttings. Mass. Agr. Expt. Sta. Bul. 491. 99 pp.

4. Duffield, J. W., and Liddicoet, A. R.
   1949. Variability of rooting in a small second generation population of the hybrid *Pinus attenuradiata*. Jour. Forestry 47: 107-109.

5. Dunn, Stuart, and Townsend, Ralph J.
   1954. Propagation of sugar maple by vegetative cuttings. Jour. Forestry 52: 678-679.

6. ---------- and Eggert, Russell.
   1959. Propagation of woody plants. N. H. Agr. Expt. Sta. Bul. 465. 12 pp.

7. Enright, L. J.
   1958. Propagation of several species of *Acer* by cuttings. Jour. Forestry 56: 426-428.

8. Gardner, F. E.
   1929. The relationship between tree age and rooting of cuttings. Proc. Amer. Soc. Hort. Sci. 26: 101-103.

9. Jalil, Mario, and Sharpe, Ralph H.
   1956. Rooting of peach cuttings under mist as affected by media and potassium nutrition. Fla. State Hort. Proc. 69: 324-327.

10. Mergen, François.
1955. Vegetative propagation of slash pine. U.S. Forest Serv. Southeast. Forest Expt. Sta. Paper 6. 63 pp.

11. Patton, R. F., and Riker, A. J.
1958. Rooting of cuttings of white pine. Forest Sci. 4: 116-127.

12. Snow, A. G., Jr.
1941. Variables affecting vegetative propagation of red and sugar maple. Jour. Forestry 39: 394-404.

13. Stout, A. B.
1929. The clone in plant life. N. Y. Bot. Garden Jour. 30: 25-37.

14. Thimann, K. V., and Behnke, J.
1950. The use of auxins in the rooting of woody cuttings. Maria Moors Cabot Foundation Pub. 1, Revised. 344 pp., Harvard Forest, Petersham, Mass.

Acknowledgments

Grateful acknowledgment is made to P. J. Kinsley, F. E. Cunningham, R. R. Morrow, H. B. Kriebel, and S. Dunn for providing plant material.

Stuart Dunn and Russell Eggert kindly allowed the authors to visit their experiment on the rooting of sugar maple cuttings and to make observations on the technique and materials they were using. The authors also are indebted to S. Nichols, E. P. Karlander, and O. R. Atkinson for help in collecting and caring for the plant material; and to W. E. McQuilkin, H. B. Kriebel, F. Mergen, S. Dunn, and L. J. Enright for their critical review of the manuscript.

WOOD · WATER · FORAGE · WILDLIFE · RECREATION

FOREST SERVICE

U S

DEPARTMENT OF AGRICULTURE